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Photographic Light-Sensitive Silver Halide Film Can Comprise A Transparent Magnetic Recording Layer. Usually Provided On The Backside Of The Photographic Support.

The magnetic layer may comprise, for example, fine ferromagnetic powders such as ferromagnetic gamma-iron oxides, cobalt surface-treated ferromagnetic iron oxides, cobalt-doped ferromagnetic iron oxides, cobalt containing Fe_2O_3 , ferromagnetic magnetites, cobalt-containing ferromagnetic magnetites, ferromagnetic chromium dioxides, ferromagnetic metal powders, ferromagnetic iron powders, ferromagnetic alloy powders and the class of ferromagnetic ferrite powders including barium ferrites.

Additionally, the above mentioned powder particles may be modified to provide lower light extinction and scattering coefficients by providing them with a shell, of at least the same volume as the magnetic core, of a low refractive index material that has its refractive index lower than the transparent polymeric material used to form the magnetizable layer. Typical shell materials may include amorphous silica, vitreous silica, glass, calcium fluoride, magnesium, lithium fluoride, polytetrafluoroethylene and fluorinated resins. Examples of the ferromagnetic alloy powders include those comprising at least 75% by weight of metals which comprise at least 80% by weight of at least one ferromagnetic metal alloy (such as Fe, Co, Ni, Fe-Co, Fe-Ni, Co-Ni, Co-Ni-Fe) and 20% or less of other components (such as Al, Si, S, Sc, Ti, V, Cr, Mn, Cu, Zn, Y, Mo, Rh, Re, Pd, Ag, Sn, B, Ba, Ta, W, Au, Hg, Pb, La, Ce, Pr, Nd, Te, and Bi). The ferromagnetic metals may contain a small amount of water, a hydroxide or an oxide.

The shape and size of the ferromagnetic powder are not particularly limited. The shape may be any needle, rice grain (prolate ellipsoid), spherical, cubic, and tabular shapes. Among them, the needle and the tabular grains are preferred from the view point of electromagnetic transduction characteristics (magnetic signal and recording performance). On the other hand, small particles of rods, prolate ellipsoids, spheres and cubic shapes or random alignment of anisometric particles are preferred on the basis of the scattering of electromagnetic radiation in respect to the extinction and scattering cross-section of the particles and the polarization of light transmitted through the magnetizable layer. Although the size and specific surface area of the crystals are not particularly limited either, the crystal size is preferably at least 20 sq. m/g, more preferably greater than 30 sq. m/g, particularly at least 40 sq. m/g. The pH of the ferromagnetic powder and the surface - treating agent therefore are not particularly limited. Namely, it can be surface treated with a substance containing an element such as titanium, silicon, or aluminum, or with an organic compound such as carboxylic acid, sulfonic acid, sulfuric ester, phosphoric acid, phosphoric ester,

or an adsorbing compound having a nitrogen-containing heterocyclic ring. Additionally, the treated ferromagnetic particles or crystals may be surrounded by a shell of a transparent material about the same volume as the core, in which the refractive index is preferably less than 1.5. Preferred pH ranges from 5 to 10. In the fine powder of ferromagnetic iron oxide and the like, the ratio of iron (II) to iron (III) is not particularly limited.

The amount of the fine ferromagnetic powder is 0.0004 to 3g, preferably 0.001 to 1g and more preferably 0.004 to 0.1g and most preferably 0.01 to 0.08 g, per sq. m of the transparent support. Any effect on the total optical density of the silver halide and transparent magnetic layer could result in longer printing times. However, this can be compensated for, at least in part, by adjusting the laydown of the masking layer in the silver halide layers. It is possible to keep the optical density of the transparent layer in the range 0.15 @ 450nm to 0.03 @ 650nm and below as determined by a spectrophotometer arranged to measure the specular density.

Binders, for the magnetic particles, usable in the present invention include known thermoplastic resins, thermosetting resins, radiation-cured resins, reactive resins and mixtures of them usually used as binders for magnetic recording media.

Tg of the resin ranges from -40 °C to 150 °C and the weight thereof ranges from 10,000 to 300,000, preferably 10,000 to 100,000.

Examples of the thermoplastic resins include vinyl copolymers (such as vinyl chloride/vinyl acetate copolymer, copolymer of vinyl chloride or vinyl acetate with vinyl alcohol, maleic acid/or acrylic acid, vinyl chloride/vinylidene chloride copolymer, vinyl chloride/acrylonitrile copolymer and ethylene/vinyl acetate copolymer), cellulose derivatives (such as nitrocellulose, cellulose acetate propionate and cellulose acetate butyrate), acrylic resin, polyvinyl acetal resin, polyvinyl butyral resin, polyester polyurethane resin, polyether polyurethane, polycarbonate polyurethane resin, polyester resin, polyether resin, polyamide resin, amino resin, rubber resins (such as styrene butadiene resin and butadiene acrylonitrile resin), silicone resin and fluorine resin.

Among them, the vinyl chloride resin is preferred, since it has a high dispersity in the fine ferromagnetic powder. Vinyl copolymers and terpolymers available on the market.

Polyester-Polyurethane resins are also available on the market.

Examples of the thermosetting resins and reactive resins include those whose molecular weights are remarkably increased by

heating such as phenolic resin, phenoxy, epoxy resin, cured polyurethane resin, urea resin, melamine resin, alkyl resin, silicone resin, acrylic reactive resin, epoxy-polyamide resin, nitrocellulose melamine resin, mixture of high molecular polyester resin and isocyanate prepolymer, urea formaldehyde resin, mixture of low molecular glycol/high molecular diol/polyisocyanate, polyamine resin and mixtures of them.

The radiation-cured resins herein include those produced by bonding the above-described thermoplastic resin with a group having a carbon-to-carbon unsaturated bond as a radiation-curable functional group. Preferred functional groups include acryloyl group and methacryloyl group.

It is preferred for the dispersibility and durability of the magnetic material to introduce a polar group (such as epoxy group, $-\text{CO}_2\text{M}$, $-\text{OH}$, $-\text{NR}_2$, $-\text{NR}_3^+$, $-\text{SO}_3\text{M}$, $-\text{PO}_3\text{M}_2$ or $-\text{OPO}_3\text{M}_2$, wherein M represents a hydrogen, alkali metal or ammonium and when the group contains plural M's, they may be the same or molecules. In such a case, the effect of the fluorine oligomer surfactant of the present invention is 10^{-7} to 10^{-3} equivalent, more preferably 10^{-6} to 10^{-4} equivalent, per gram of the polymer.

The above-described polymer binders are used either solely or in the form of a mixture of two or more of them. Further, a known isocyanate crosslinking agent and/or a radiation-curable vinyl monomer can be incorporated therein to cure it.

Examples of the isocyanate cross linking agents include polyisocyanate compounds having two or more isocyanate groups such as tolyene diisocyanate, 4,4'-diphenylmethane diisocyanate, hexamethylene diisocyanate, xylylene diisocyanate, naphthylene-1,5-diisocyanate, o-toluidine diisocyanate, isophorone and polysocyanates formed by condensation of these isocyanates.

The radiation-curable vinyl monomers are compounds polymerizable by radiation and having at least one carbon-to-carbon unsaturated bond in the molecule such as (meth)acrylic esters, (meth)acrylamides, allyl compounds, vinyl ethers, vinyl esters, vinyl heterocyclic compounds, N-vinyl compounds, styrene, two (meth)acryloyl groups such as polyethylene glycol (meth)acrylates, e.g. diethylene glycol di(meth)acrylate and triethylene glycol di(meth)acrylate, trimethylolpropane tri(meth)acrylate, pentaerythritol tetraproduct of a polyisocyanate with a hydroxy(meth)acrylate compound.

The amount of such a crosslinking agent is preferably 5 to 45% by weight based on the total binders including this crosslinking agent.

A hydrophilic binder can be incorporated into the magnetic recording layer of the present invention.

The hydrophilic binders usable herein are described in Research Disclosure No. 308119 December 1989 and No. 18716 (p. 651) November 1979. Examples of them given therein include water-soluble polymers, cellulose esters, latex derivatives, casein, agar, sodium alginate, starch, polyvinyl alcohol, polyacrylic acid copolymers and maleic anhydride copolymers. The cellulose esters include hydroxyl propyl cellulose, carboxymethyl cellulose and hydroxyethyl cellulose. The latex polymers include vinyl chloride copolymers, vinylidene chloride copolymers, acrylic ester copolymers, vinyl acetate copolymers and butadiene copolymers. Among them, gelatin is most preferred.

Gelatin may be any of so-called alkali-treated (lime treated) gelatin which was immersed in an alkali bath prior to extraction thereof, an acid-treated gelatin which was immersed in both baths and enzyme-treated gelatin. If necessary, gelatin can be used in combination with colloidal albumin, casein, a cellulose derivative (such as carboxymethyl or hydroxyethyl cellulose), agar, sodium alginate, a saccharide derivative (such as a starch derivative or dextran), a synthetic hydrophilic colloid (such as polyvinyl alcohol, poly-N-vinylpyrrolidone, a polyacrylic acid copolymer, polyacrylamide or a derivative or partial hydrolyzate thereof) or a gelatin derivative.

It is preferred to harden the magnetic recording layer containing gelatin. Hardeners usable for hardening the magnetic recording layer include, for example, aldehyde compounds such as formaldehyde and glutaraldehyde; ketone compounds such as diacetyl and cyclopentanone; compounds having reactive halogens such as bis(2-chloroethylurea), 2-hydrox-4, 6-dichloro-1, 3, 5-triazine and those described in U.S. Patent Nos. 3,288,775 and 2,732,303 and British Patent Nos. 974,723 and 1,167,207; divinylsulfone, 5-acetyl-1, 3-diacrylohexahydro-1, 3, 5-triazine and compounds having reactive olefens described in U.S. Patent Nos. 3,635,718 and 3,232,763 and British Patent No. 994,869; N-hydroxymethylolthalamide; N-methylol compounds described in U.S. Patent Nos. 2,732,316 and 2,586,168; isocyanates described in U.S. Patent No. 3,103,437; aziridine compounds described in U.S. Patent Nos. 3,017,280 and 2,983,611; acid derivatives described in U.S. Patent Nos. 2,725,294 and 2,725,295; epoxy compounds described in U.S. Patent No. 3,091,537; and halogenated carboxyaldehydes such as mucochloric acid. Examples of the carboxyl group activating type described in Japanese Patent Publication for opposition purpose (hereinafter referred to as "J.P. KOKOKU") Nos. 56-12853 and 58-32699, Belgian Patent No. 825,726, J.P. KOKAI Nos. 60-225148 and 51-126125, J.P. KOKOKU No. 58-50699, J.P. KOKAI No. 52-54427 and U.S. Patent No. 3,321,313.

The amount of the hardener is usually 0.01 to 30% by weight, preferably 0.05 to 20% by weight based on dry gelatin.

The thickness of the magnetic recording layer is 0.1 to 10µm, preferably 0.3 to 5µm and more preferably 0.5 to 3µm, most preferably 0.5 to 1.25µm.

The magnetic recording layer of the present invention may contain as antistatic agent, lubricant, matting agent and surfactant, a pigment dispersing aid and plasticizer. The lubricants usable herein include saturated and unsaturated fatty acids (such as fatty acids, e.g. myristic acid, stearic acid and oleic acid and a mixture of fatty acids produced by decomposing a natural animal or vegetable and, if necessary, hydrogenating the decomposition products); metallic soaps; N-substituted or N-unsubstituted fatty acid amides; fatty acid esters (such as monoesters e.g. butyl myristate, isocetyl stearate ethyl hexyl palmitate, fatty acid esters of polyhydric compounds, e.g. sorbitan and glycerol, and esterified polybasic acids); ester compounds having ether bond; higher aliphatic alcohols; monoalkyl phosphates; dialkyl phosphates; trialkyl phosphates; paraffins; silicone oil; vegetable and animal oils; mineral oils; higher aliphatic amines; fine powders of inorganic substances such as graphite, silica, molybdenum disulfide and tungsten disulfide.

A pigment dispersing agent, sometimes referred to as a wetting agent or a surface active agent, can be present in the solvent to facilitate dispersion of the magnetic particles and/or wetting the particles with the solvent. This helps to further minimize agglomeration of magnetic particles which would reduce the transparency and increase graininess of the photographic support and images contained thereon. Useful dispersing agents include a fatty acid amine and commercially available wetting agents such as a quaternary amine propylene oxide ether. Other agents include alkyl or aryl phosphoric acid mono and di-ester with polyethylene oxide functionality.

The plasticizer and nonvolatile solvent can be an ester of an acid such as phthalic acid.

The magnetic layer comprising ferromagnetic fine powder particles, polymeric binders, surface treatment agents and lubricants has been described by:

Krali	US Patent	3,782,947
Audran et al	US Patent	4,279,945
	US Patent	4,302,523
Bishop et al	US Patent	4,990,276
Yudelso	US Patent	4,994,304

Reith & James	US Patent	4,871,218
	PCT/US	US91/00579

Bertucci James & Olean	PCT/US	US91/08050
	PCT/US	US91/08051

Yamamoto et al	US Patent	3,870,525
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Watanabe	Euro. Pat App.	0 459 349
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Sakakibara	Euro. Pat App.	0 466 130
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Arai	US Patent	4,911,997
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The magnetic recording layer of the present invention may contain as part of or as one or more separate layers, an antistatic agent, a lubricant, an abrasive, a matting agent and surfactant.

Examples of the antistatic agents include electroconductive fine powders such as carbon black and carbon black graft polymers; natural surfactants such as saponin; nonionic surfactants such as alkylene oxides, glycerols and glycidols; cationic surfactants such as higher alkylamines, quaternary ammonium salts, salts of heterocyclic compounds, e.g. pyridine, phosphoniums and sulfoniums; anionic surfactants having an acid group such as carboxylic acid, phosphoric acid, sulfuric ester or phosphoric ester group; and amphoteric surfactants such as amino acids, aminosulfonic acids, and sulfuric or phosphoric esters of amino alcohols.

The lubricants usable herein include saturated and unsaturated fatty acids (such as fatty acids e.g. myristic acid, stearic acid and oleic acid and a mixture of fatty acids produced by decomposing a natural animal or vegetable oil and, if necessary, hydrogenating the decomposition products); metallic soaps; N-substituted or N-unsubstituted fatty acid amides; fatty acid ester (such as monoesters, e.g. butyl myristate, isocetyl stearate, ethyl butyl palmitate, fatty acid esters of polyhydric compounds, e.g. sorbitan and glycerol, and esterified polybasic acids); ester compounds having an ether bond; higher aliphatic alcohols; monoalkyl phosphates; dialkyl phosphates; trialkyl phosphates; paraffins; silicone oil; vegetable and animal oils; mineral oils; higher aliphatic amines; fine powders of inorganic substances such as graphite, silica, molybdenum disulfide and tungsten disulfide; and resins such as polyethylene, polypropylene, polyvinyl chloride, ethylene/vinyl chloride copolymer and polytetrafluoroethylene.

The magnetic recording layer is formed preferably on the back surface of the photosensitive material. This layer can be formed on the back surface of a transparent support by application printing. It is also preferred to prepare a transparent support having a magnetic recording layer by casting a polymer solution containing magnetized grains dispersed therein together with a polymer solution for forming the transparent support. In this case, the compositions of the two polymers are preferably substantially the same.

The magnetic recording layer may have lubricity-improving effect, curl-controlling effect, antistatic effect and adhesion-inhibiting effect or, alternatively, other functional layers may be provided to impart these functions to the photosensitive material. If necessary, a protecting layer adjacent to the magnetic recording layer may be formed to improve scarring resistance thereof.

Formation of the magnetic layer used in the present invention is carried out by dispersing a ferromagnetic substance in a binder, additive and solvent to prepare a coating composition, coating the resulting coating composition onto a support and then drying. The ferromagnetic substance, binder, dispersing agent, lubricant, abrasive, antistatic agent and solvent were blended and milled or kneaded to prepare a magnetic coating composition. For milling or kneading the magnetic powder and other components as set forth above are charged in a kneading machine simultaneously or separately. For example, a magnetic powder is added to a solvent containing a dispersing agent and mixed, milled, or kneaded for a predetermined period of time to prepare a magnetic coating composition.

Various kneading machines are used for the kneading and dispersing of the magnetic coating composition, for example, two roll mills, three roll mills, ball mills, pebble mills, trommel mills, sand grinders, Szegvari attriters, high speed impeller dispersing machines, high speed stone mills, high speed small media mills e.g. using steel, ceramic or glass dispersing high speed mixers, homogenizers, ultrasonic machines and the like. The kneading and dispersing techniques are described in T.C. Patton, "Paint Flow and Pigment Dispersion", published by John Wiley & Sons (1964) and U.S. Pat. Nos. 2,581,414 and 2,855,156.

The foregoing magnetic recording layer can be coated on a support using coating methods such as air doctor coating, blade coating, rod coating, extrusion coating, air knife coating, squeeze coating, dip coating, reverse roll coating, gravure coating, kiss coating, cast coating, spray coating, spin coating and the like, and the other coating methods can also be used. These methods are described in "Coating Kogaku (Coating Engineering)", page 253-277, published by Asakura Shoten, Tokyo (Mar. 20, 1971).

The magnetic layer coated onto a support by the above described coating method is dried after, if necessary, the coating has been subjected to a treatment for orienting the magnetic substance in the layer. If necessary, the magnetic layer can be subjected to a surface-smoothing treatment or cut in any desired shape, thereby to form the magnetic recording medium.

According to the present invention, in particular, it is found that when the magnetic layer is subjected to a surface-smoothing treatment, a magnetic recording medium can be obtained with a smooth surface as well as an excellent abrasion resistance. This surface smoothing treatment is carried out by a smoothing treatment before drying or by a calendaring treatment after drying.

As the support, there are used for example, polyesters such as polyethylene terephthalate and polyethylene-2, 6-naphthalate, polycarbonates, polyamides, polyimides, polyamideimides, polyolefins such as polypropylene, cellulose derivative such as cellulose triacetate and cellulose diacetate and the like.

When the above described non-magnetic support is in the form of a film, tape, sheet or card, it can be subjected to coating on the magnetic layer provided thereon for the purpose of preventing static charging, magnetic print through and wow and flutter, increasing the strength of the magnetic recording medium and matting the back surface.

The smoothness, signal/noise ratio of the magnetic signals and the durability can be improved by calendaring the back surface of the transparent support having the magnetic recording layer. In this case, a photosensitive layer is preferably formed by coating on the transparent support after the calendaring process.

APPENDIX

PHOTOGRAPHIC SUPPORT:

cellulose acetate & derivative
cellulose triacetate
cellulose diacetate
polyethylene terephthalate
polyethylene - 2,6 - naphthalate
polycarbonates
polyamides
polyimides
polyolefins
resin coated photographic paper
low density polyethylene
high density polyethylene

The dispersion in accordance with this invention contains magnetic particles which preferably are acicular or needle like magnetic particles. The average length of these particles along the major axis preferably is less than about 0.3, more preferably, less than about 0.2 micron. The particles preferably exhibit an axial ratio, that is, a length to diameter thickness ratio of up to about 5 or 6 to 1. Preferred particles have a specific surface area of at least 30m²/g, more preferably of at least 40m²/g. Typical acicular particles of this type include, for example, particles of ferro and ferro iron oxides such as gamma-ferrie oxide, complex oxides of iron and cobalt, various ferrites and metallic iron pigments. Alternatively, small tabular particles such as barium ferrites and the like can be employed. The particles can be doped with one or more ions of a polyvalent metal such as titanium, tin, cobalt, nickel, zinc, manganese, chromium, or the like as is known in the art. A preferred particle consist of Co surface treated gamma-Fe₂O₃ having a specific surface area of greater than 40 m²/g. Particles of this type are commercially available. For good magnetic recording, the magnetic particles preferably exhibit coercive force above 500 Oe (e.g. about 800 Oe) and saturation magnetization above 70 emu/g of iron oxide (not including any shell that may be coated on a magnetic core particle.)

The magnetic particles can be present in the dispersion in an amount of from about 25% to 75% by weight. In particular in preferred embodiments, the magnetic particles are present in an amount of 30% to 50% by weight.

APPENDIX

4,990,276

The dispersion of this patent includes a dispersing medium. The dispersing medium preferably is a nonvolatile solvent which can be an ester of an acid such as phthalic acid. Preferred esters are dialkylesters of phthalic acid, the alkyl portion of which can contain from 1 to about 12, preferably 4 to 8, carbon atoms. Exemplary useful esters include dimethyl phthalate, diethyl phthalate, dioctyl phthalate, dipropyl phthalate, dibutyl phthalate, di-2-ethylhexyl phthalate and the like. The dialkylesters of phthalic acid are readily prepared and are advantageous compared to other esters of phthalic acid such as dimethoxy ethyl phthalate which has been prepared using hazardous solvents such as cellosolve. The dispersing medium can be present in the dispersion during milling in an amount of about 40 - 70%, more preferably 50 - 65%, by weight. All percentages herein, unless otherwise indicated, refer to percentages by weight based on the total weight of the dispersion.

Antistatic agents which can be used include electroconductive fine powders such as carbon black graft polymers; natural surface active agents such as saponin; nonionic surface agents such as alkylene oxide based, glycerol based and glycidol based surface active agents; cationic surface active agents such as higher alkylamines, quarternary ammonium salts, heterocyclic compounds such as pyridine and the like; phosphonium or sulfonium salts and the like; anionic surface active agents containing acid groups such as carboxylic acid, sulfonic acid, phosphoric acid, sulfate, phosphate groups and the like; and amphoteric surface active agents such as amino acids, aminosulfonic acids and sulfuric acid or phosphoric acid esters of amino alcohols and the like.

The above described electroconductive fine powders are generally added in a proportion of 0.2 to 20 parts by weight to 100 parts by weight of the binder and the surface active agents are generally added in a proportion of 0.1 to 10 parts by weight to 100 parts by weight of the binder.

Suitable lubricants which can be used in the present invention include silicone oils such as dialkylpolysiloxanes (alkyl: C₁-C₅), dialkoxypolysiloxanes (alkoxy: C₁-C₄), monoalkylmonoalkoxypolysiloxanes (alkyl: C₁-C₅; alkoxy: C₁-C₄), phenylpolysiloxanes and fluoroalkylpolysiloxanes (alkyl: C₁-C₅); electroconductive fine powders such as graphite powder; inorganic fine powders such as polyethylene, polypropylene, ethylene-vinyl chloride copolymers and polytetrafluoroethylene powders; alpha-olefin polymers; unsaturated aliphatic hydrocarbons liquid at normal temperature (wherein double bond of

n-olefin is bonded to terminal carbon, number of carbon atoms: about 20); fatty acid esters of monobasic fatty acids of C₁₂ - C₂₀ and monohydric alcohols of C₃ - C₁₂; and fluorocarbons. These lubricants are generally used in a proportion of 0.2 to 20 parts by weight to 100 parts by weight of the binder.

Typical abrasive agents which can be used in the present invention include fused alumina, silicon carbide, chromium oxide (Cr₂O₃), corundum, diamond, synthetic corundum, synthetic diamond, garnet, emery (main component: corundum and magnetite) and the like. These abrasive agents have generally a Mohs' hardness of 5 or more and a mean grain size of 0.05 to 5 microns, and are generally used in a proportion of 0.5 to 20 parts by weight is 100 parts by weight of the binder.

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Thermal Break for Cards with Redundant Ground or Power Planes

Printed circuit boards requiring redundant ground and voltage planes can cause an insufficient solder fill condition. The idea to add more plated through holes (PTH) around the perimeter of the redundant plane connections facilitates the transfer of more heat from the solder operation which aids in complete hole fill.

To facilitate better heat transfer into redundant ground and voltage plane connections to obtain better solder fillets can be done by changing these three design rules on printed circuit boards:

1. Have only single ground and voltage planes to the perimeter pins on a module.
2. By ground rules, add a complete extra row of PTHs around the module in the same grid pattern.
3. Add 3 extra PTHs around the adjacent PTHs with the redundant ground pins. If the module pinout pattern does not contain a full matrix of holes, it may be necessary to add extra PTHs within the PTH pattern to obtain a full matrix of holes, again to facilitate good heat transfer to the PTHs with redundant ground and voltage planes. If these design changes are made, a better quality solder fillet can be obtained at a higher throughput rate on the solder wave.

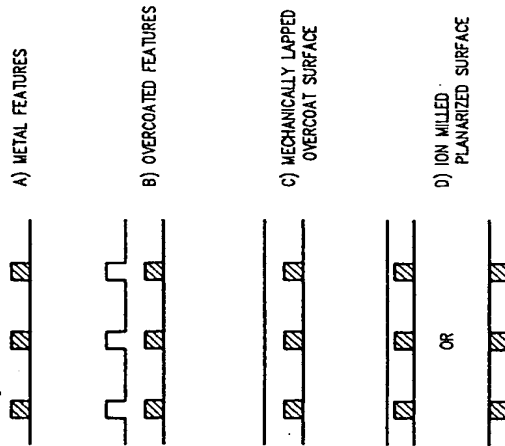
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A Hybrid Planarization Process

Disclosed is a planarization process for metal features on substrate surfaces. A dielectric material is used as an overcoat layer. The process employs mechanical lapping to planarize the dielectric layer over the metal features and uses ion beam milling to precisely control the final thickness of the dielectric material above the metal features. In applications where the dielectric material is completely removed above the metal features a planar metal-dielectric surface is achieved.

The process is illustrated in Figure 1. Dielectric material is deposited over the metal features. The dielectric layer thickness is greater than the height of the metal features. Mechanical lapping is used to remove the features which have been replicated into the dielectric layer. Initially the lapping force is applied only to the featured areas and rapid material removal results. When planarization is achieved the lapping force is distributed over the entire substrate surface and the material removal rate decreases. After the decrease in removal rate of overcoat material is observed, the planarized surface is ion beam milled to precisely reduce the overcoat material thickness to a desired final value.

Mechanical lapping has the advantage of large material rates but the disadvantage of precise endpoint control. Ion beam milling has the advantage of controlled material removal but at slow rates. The combination of both techniques results in an efficient and precise hybrid planarization process for metal features.



HYBRID PLANARIZATION PROCESS

FIG. 1

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